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CHANGE HISTORY LOG

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RANGE SAFETY MANUAL

FOR

GODDARD SPACE FLIGHT CENTER (GSFC)/ WALLOPS FLIGHT FACILITY (WFF)

June 23, 1993

National Aeronautics and
Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia 23337-5099

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FOREWORD

Safety is the responsibility of all National Aeronautic and Space Administration (NASA) personnel, NASA contractors, tenants, experimenters, and range users while conducting operations at NASA Goddard Space Flight Center/Wallops Flight Facility (GSFC/WFF) or other off-range locations. This requires a concerted effort by all personnel to operate in a manner that will minimize the risks inherent in performing rocket, aircraft, balloon, and associated operations. This document identifies the range safety requirements established by GSFC/WFF for implementing GMI 1771.1 to insure that risk are controlled and minimized.

Safety participation early in the planning stages of a program will reduce the possibility of costly engineering changes and/or scheduling delays. Therefore, coordination with the GSFC/WFF Ground and Flight Safety Section (GFSS) should be established through the Range Support Manager as early in the planning stages of a program as possible. GSFC/WFF GFSS personnel should be notified of and be represented at technical interchange meetings, preliminary design, system design and critical design reviews, and flight readiness reviews, where ground and flight safety issues are addressed.

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REFERENCES

Reference:

(a) GMI 1771.1, Range Safety Policies and Criteria for GSFC/WFF
(b) GMI 1300.2, Policies and Procedures for the Use of GSFC/WFF Test Range
(c) Aircraft Operations Manual for Wallops Flight Facility
(d) DoD Standard 6055.9, Ammunition and Explosive Standards
(e) NSS/GO-1740.9, NASA Safety Standard for Lifting Devices and Equipment
(f) ANSI C95.1-1982, American National Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 30 KHz to 100 GHz
(g) GHB 1860.2, Radiation Safety Handbook
(h) Title 10, Code of Federal Regulations (CFR), Parts 19 and 20
(i) GHB 1860.1B, Radiation Protection -- Ionizing Radiation
(j) ANSI Z136.1-1986, American National Standard for the Safe Use of Lasers
(k) GHB 1860.3, Radiation Safety Handbook -- Laser
(l) National Electric Code, Article 500 - Explosion Proof Hardware Specifications
(m) CPIA Publication 394, Hazards of Chemical Rockets and Propellants
(n) ASME Boiler and Pressure Vessel Code
(o) GMI 1710.4; Design, Inspection, and Certification of Pressure Vessels and Pressurized Systems
(p) MIL STD 1522A, Standard General Requirements for Safe Design and Operation of Pressurized Missile & Space Systems, May 28, 1984.
(q) UN Document "Transport of Dangerous Goods"
(r) Range Commanders Council Document (RCCD) "Flight Termination Systems Commonality Standard" Standard 319-92
(s) Federal Aviation Regulations, Part 101
(t) VACAPES Operating Instruction, 3120.1F
(u) GMI 1710.6, Design, Inspection, and Certification of Lifting Devices and Equipment, Revision 1, March 13, 1989.

1.0 INTRODUCTION

1.1 Purpose

1.1.1 Identify GSFC/WFF range requirements to implement safety policies and criteria defined in GMI 1771.1 (Reference a).

1.1.2 Define specific design requirements, restrictions, operational procedures, and support requirements.

1.1.3 Identify data requirements necessary for GSFC/WFF to perform appropriate safety analyses and grant approval to conduct operations.

1.1.4 Acquaint range users with the range safety organization at GSFC/WFF.

1.2 Scope

1.2.1 Applicability

1.2.1.1 This document is applicable to all Programmatic Operations and specific aircraft operations conducted at or managed by GSFC/WFF. It is applicable to all NASA personnel, NASA contractors, tenants, experimenters, and range users. It is the responsibility of all personnel to acquaint themselves with the requirements set forth in this document, GMI 1771.1 (Reference a) and GMI 1300.2 (Reference b).

1.2.1.2 For aircraft operations, this document is applicable for hazardous systems incorporated within or attached to aircraft platforms, operations conducted on the GSFC/WFF test range, and operations which expose the public to risk greater than that incurred by normal aircraft operations. Aircraft operational requirements for the WFF airfield are defined in the Aircraft Operations Manual for Wallops Flight Facility (Reference c).

1.2.2 For GSFC/WFF managed operations conducted at other ranges, the requirements established by this document shall be used as a minimum unless requirements of the host range are more stringent, in which case the more stringent requirements will apply.

1.2.3 More stringent safety requirements will be considered by GSFC/WFF if requested by the range users, experimenters, or tenants.

1.3 Policy

It is GSFC/WFF policy to conduct all operations within the risk levels specified by GMI 1771.1. This manual defines the specific requirements which shall be met to implement this policy. In cases where requirements cannot be satisfied, a safety analysis report approved by the Director of Suborbital Projects and Operations is required.

2.0 RANGE SAFETY ORGANIZATION AND RESPONSIBILITIES

Range Safety responsibilities are defined in References a and b and are summarized in this document for clarity.

2.1 The responsibility for safety at the GSFC/WFF is vested in the Director, GSFC. The Safety and Quality Assurance Engineering Branch, the Launch Vehicles Branch, and the Aircraft Programs Branch (APB) of the Suborbital Projects and Operations Directorate are charged with the responsibility for implementing the range safety policies and criteria, and conducting operations at the GSFC/WFF, as defined in GMI 1771.1 (Reference a).

2.2 The Ground and Flight Safety Section (GFSS) is responsible for performing safety analyses and developing Ground and Flight Safety Plans or Data Packages for all applicable programmatic missions including rocket, balloon, and aircraft. For tenant generated safety plans, the GFSS is responsible for review and approval of these plans.

2.3 The GSFC/WFF Range Safety Officer (RSO) is responsible for implementing flight safety and for ensuring a Ground Safety Program is developed and implemented.

2.4 The GSFC/WFF Operations Safety Supervisor (OSS) is responsible for supervising all potentially hazardous operations for which he/she has been assigned. The OSS is also responsible for implementation of Ground Safety Plans and operating procedures. In some instances the OSS may delegate his responsibilities to other qualified personnel for specific operations.

2.5 The responsibility of implementing GSFC/WFF safety policy, criteria, and planning at ranges other than GSFC/WFF shall be delegated according to the following hierarchy:

a. The GSFC/WFF RSO*

b. The GSFC/WFF Campaign Manager

c. The GSFC/WFF Payload Manager

* Poker Flat Research Range (PFRR) Range Safety Officer or designee at PFRR; National Scientific Balloon Facility (NSBF) Head of Balloon Operations or designee for NSBF.

2.6 For the Balloon Program, the Head, Balloon Projects Branch shall assure that 1) the requirements and procedures defined in appropriate safety plans and balloon risk analysis are implemented, and 2) the operational responsibilities normally assigned to the RSO, OSS, or Project or Campaign Manager in this document are implemented for balloon operations.

3.0 RANGE USERS PRE-ARRIVAL REQUIREMENTS

3.1 Range users shall design their systems to conform to the requirements established by this document.

3.2 For operations other than balloons, range users shall prepare and provide to GSFC/WFF formal documentation pertaining to the project for safety review. This documentation shall include information describing their ground and flight systems, operating procedures, and unique requirements of the project. Specific details of the data required are provided in Section 8.0.

3.3 For balloon operations, range users shall provide data necessary for NSBF to assure the program meets a SAR or Balloon Ground Safety Plan requirements.

3.4 Prior to arrival at GSFC/WFF, range users shall submit written requests for waivers to the GSFC/WFF Range Support Manager or to the Head, Balloon Projects Branch (as appropriate) for any requirements of this document which cannot be satisfied.

4.0 DEFINITIONS

See Enclosure A.

5.0 GROUND SAFETY

5.1 General

5.1.1 The ground safety goal of GSFC/WFF is to minimize the risks to personnel and property involved in conducting operations at GSFC/WFF and to prevent mishaps that would result in embarrassment to NASA or the United States Government.

5.1.2 It is required that all systems be designed such that a minimum of two independent unlikely failures shall occur in order to expose personnel to a hazard.

5.2 Hazard Control

5.2.1 Hazard Control Methods

The methods employed by GSFC/WFF to protect personnel and property and to minimize the risk in conducting potentially hazardous operations are:

* Identify all the known hazards associated with the program.
* Implement safety design criteria.
* Minimize exposure of personnel to hazardous systems.
* Establish safe operating procedures.
* Plan for contingencies.

5.2.2 Exposure Limits

The cardinal principle to be observed in any location or operation involving explosives, severe fire hazards, high pressure systems, or other hazardous materials, shall be to limit the exposure to a minimum number of personnel, to a minimum time, and to a minimum number of potential hazards, consistent with safe and efficient operations. Operations shall be arranged such that, should an incident occur, it will cause the least possible injury to personnel and damage to facilities or surrounding property. Operations shall be conducted in a manner such that the distance a person is from a hazardous system increases as the possibility of actuating the system increases.

5.2.3 Personnel Limits

5.2.3.1 Only active essential personnel (No less than 2 and no more than 12) shall be permitted on launch pads, in explosives handling areas, or other hazardous areas. This limit includes supervisors, range users, and others determined necessary by the Operations Safety Supervisor. The Head, Launch Vehicles Branch and the Head, Safety & Quality Assurance Engineering Branch may grant exceptions following review of formal requests.

5.2.3.2 The Operations Safety Supervisor (or other NASA official in charge of the operation) shall assure that the number of personnel performing potentially hazardous tasks are kept to a minimum.

5.2.3.3 For off-range operations, WFF employees (NASA and/or contractor) shall abide by the requirements of the launch range conducting the operation(s) if that range has requirements or limits more stringent than WFF.

5.2.3.4 The GSFC/WFF Operations Safety Supervisor shall determine the number of personnel necessary to perform each task.

5.2.3.5 Requirements regarding official visitors or guests, tours, etc. are as follows:

5.2.3.5.1 Early notification of an impending visit or tour shall be given to the Operations Safety Supervisor responsible for the operations prior to the individual or group arrival. Potentially hazardous operations or tasks shall be brought to a safe stopping place (Category "B" state) and all work on hazardous systems will cease while the tour is in progress.

5.2.3.5.2 If the hazardous system cannot be placed in a Category "B" status (e.g., pad arming has already occurred), and it has been determined by the Chief, Operations Division (or his designee), that the visit is necessary, the Operations Safety Supervisor and the Range Safety Officer (RSO) shall determine the most convenient time and duration for the visit.

5.2.3.5.3 For operations at other ranges (mobile or permanent), the GSFC/WFF lead manager (Campaign Manager, Program Manager, or Project Manager), in conjunction with the local safety official(s) shall determine the necessity of the visit or tour and will determine the most convenient time, consistent with safety policies/requirements for the visit to occur.

5.2.3.5.4 Tour groups will be accompanied by a person of authority such as the Operations Safety Supervisor and will consist of no more than twelve (12) people. The twelve (12) people will include the Tour Guide (Supervisor, Campaign Manager, Payload Manager, Project Manager, or their designee). If the group is larger than twelve (12), it will be split into as many smaller groups as are necessary to maintain the limit.

5.2.3.5.5 Members of the tour group shall not be permitted to touch or handle any ordnance or other hazardous hardware.

5.2.3.5.6 All area-specific safety requirements shall be enforced (i.e. safety glasses, hard hats grounding, clothing, etc.). The person of authority shall determine the necessity of wearing static dissipative garments when in the vicinity of explosives or other static sensitive materials.

5.2.4 Ground Safety Plan

5.2.4.1 A Ground Safety Plan will be prepared by the Ground and Flight Safety Section prior to any potentially hazardous operation or launch conducted at GSFC/WFF. This plan will identify the potential hazards and describe the system designs and methods employed to control the hazards. This plan shall also establish controls to protect high value property, as required.

5.2.4.2 For launch or other potentially hazardous ground operations conducted at other ranges, this information shall be provided in a Ground Safety Plan or Ground Safety Data Package.

5.2.4.3 Where applicable, a general Ground Safety Plan may be prepared for repetitive operations/programs which shall identify safety planning for all potential hazards. This plan may be augmented for mission operations by a mission specific Ground Safety Plan.

5.2.5 Hazard Categories

Hazard categories are established to differentiate between hazardous and non-hazardous systems. Each system is analyzed and categorized as either Category "A", Category "B", or Category “A/B”. All hazardous systems shall be considered Category "A" until Category "B" conditions have been determined and approved.

5.2.5.1 Category "A" systems are those systems which meet all the following: (1) initiation of the system could lead to a chain of events which result in injury or death to personnel or damage to property; (2) sufficient potential energy exists to initiate the device; and (3) the energy output of the system is not controlled by approved mechanical restraints or other safety devices.

5.2.5.2 Category “B” systems are those systems which (1) are highly improbable of being initiated, or (2) shall not cause injury to personnel or damage to property by either the expenditure of their own energy or the chain of events they initiate.

5.2.5.3 Category "A/B" systems are those systems which change from Category "B" to Category “A” during the various stages of processing. The change in hazard category is accomplished by utilizing approved out-of-line SAFE/ARM devices, mechanical restraining devices, employing the Man-Rated design requirements defined in 5.3.4.4.5 or 5.3.11, or by other approved means which reduce the effects of an inadvertent actuation to a nonhazardous condition or reduces the probability of occurrence to acceptable levels. The Category “A” or Category “B” requirements shall apply as appropriate.

5.2.5.4 The classification of each system, the devices or means of reducing the classification level, the danger area, restrictions, and list of responsible persons shall be identified in the Ground Safety Plan or Ground Safety Data Package for each program.

5.2.6 Multiple Operations

Multiple unrelated operations shall not be conducted simultaneously within a single operational danger area unless the operations are reviewed and specifically approved by the Head, Ground and Flight Safety Section or his designee. When such approval is granted, the operations shall not exceed personnel limits established in 5.2.3.

5.3 Specific Policies and Criteria

5.3.1 Hazard Categorization

5.3.1.1 All hazardous systems, including electrical, chemical, pressure etc., shall be categorized into either hazard category “A”, “B”, or “A/B”.

5.3.1.2 Hazardous systems shall be assumed Category "A" until conditions have been met which shall permit a change to Category "B". Category "A" systems can be categorized Category "A/B" when any of the following conditions exist:

5.3.1.2.1 Approved restraining devices are employed to reduce the effects of an inadvertent actuation to a nonhazardous condition.

5.3.1.2.2 The hazardous system is installed, but not connected to its controlling electrical circuit. Hazardous ordnance systems shall also have their EED’s shorted, grounded, and shielded.

5.3.1.2.3 Ordnance systems employ an approved mechanical or electro-mechanical SAFE/ARM device which provides an out-of-line feature in the SAFE position.

5.3.1.2.4 Systems employ the Man Rated circuit design requirements established in 5.3.4.4.5

5.3.1.2.5 For hazardous chemical systems, the system is closed, contains two independent verifiable safeties in the flow path, and leak integrity is verified .

5.3.1.2.6 For pressure systems, the pressure is steady-state and less than or equal to the Maximum Allowable Working Pressure (MAWP). The MAWP is defined as the maximum pressure to which personnel may be exposed, and is synonymous with Maximum Expected Operating Pressure (MEOP) as defined in MIL-STD 1522A (Reference p).

5.3.1.3 For Category "A/B" systems, the change from Category “B” to a Category "A" shall be performed as late as possible in the processing sequence.

5.3.2 Danger Areas

For all hazardous systems, a danger area shall be defined which will adequately contain the hazard and protect personnel should an inadvertent actuation occur. Restrictions shall be established to prohibit access into the danger area when the possibility of initiating the hazardous system exists.

5.3.2.1 Prelaunch and Launch Danger Areas shall be defined in the Ground Safety Plan/Data Package for each mission.

5.3.2.2 Mission-specific danger areas for chemical, pressure, radiation, or other hazardous subsystems shall be defined on a case-by-case basis and shall be identified in the Ground Safety Plan/Data Package for that mission.

5.3.2.3 Flight control danger areas and their implementation shall be defined in the Ground Safety Plan/Ground Safety Data Package when applicable.

5.3.3 Operations/Design Considerations

5.3.3.1 This document allows range users to utilize various acceptable design techniques defined in 5.3.4. Prelaunch operational requirements should be a factor in selecting a specific design because operations which require personnel to be located inside danger areas during power switching, power on, and RF transmissions can only be performed if:

(1) the system is in a Category "B" condition, or
(2) the Man-Rated design defined by 5.3.4.4.5 is employed.

5.3.3.2 Category "A" systems may be converted to a Category "B" state by implementing any of the requirements cited in paragraph 5.2.5.3.

5.3.3.3 All Category “A” danger areas shall be cleared of personnel for operations which require power switching, power ON, or RF transmissions, except as identified in 5.3.3.8.

5.3.3.4 Personnel may be allowed in the danger area of Category "A" system whenever there are no power switching, power ON, or RF transmissions occurring and two independent inhibits are verified in place.

5.3.3.5 No personnel shall be allowed within the danger area of a Category “A” system if the system has been reduced to only one inhibit.

5.3.3.6 Prior to switching Ground Support Equipment (i.e. vacuum systems, heaters, etc.) ON for the first time, the applicable danger area will be cleared of all personnel regardless of the system status.

5.3.3.7 Prior to making an electrical change on a non-hazardous (Category "B") system all personnel in the vicinity shall be notified of the impending event.

5.3.3.8 Personnel may be allowed in danger areas to perform work external to the vehicle when power is supplied to a Category "A" system and no power switching is occurring. This operation shall be specifically approved by the Head, Ground and Flight Safety Section, or his designee and can only occur after power has been cycled several times and has remained ON in a steady state condition for a reasonable amount of time.

5.3.4 Hazardous Circuit Design Requirements

5.3.4.1 All circuits which initiate ordnance devices or initiate other hazardous systems shall be approved by the Ground & Flight Safety Section prior to granting approval for use at GSFC/WFF.

5.3.4.2 Category "B" System Requirements

Category "B" systems shall contain a minimum of two independent safety devices which prevent an inadvertent actuation.

5.3.4.3 Category “A/B” system requirements

5.3.4.3.1 The electrical circuit shall contain a minimum of two independent open contacts between the power source and the system initiator.

5.3.4.3.2 The system shall be designed such that the conversion from Category “B” to Category “A” shall minimize personnel exposure to the hazard. The final conversion to Category “A” shall occur during arming operations.

5.3.4.3.3 Mechanical restraint designs shall be approved by the Head, Safety and Quality Assurance Engineering Branch, or his designee.

5.3.4.4 Category "A" System Requirements

5.3.4.4.1 All circuits initiating Category "A" devices or systems shall satisfy the circuit design criteria identified below.

5.3.4.4.1.1 All Electroexplosive Devices (EEDs) shall meet a 1 amp/1 watt NO FIRE requirement and be 100% qualified with a 500 VDC megohmmeter test for 5 seconds from bridgewire to case (and bridgewire to bridgewire if dual bridgewires are used) unless an exemption is granted by the Head, Safety and Quality Assurance Engineering Branch, or his designee.

5.3.4.4.1.2 Electrical wiring and power source shall be completely independent and isolated from all other systems; they shall not share common cables, terminals, power sources, tie points, or connectors with any other system.

5.3.4.4.1.3 All circuit wiring shall be twisted and shielded and independent of all other systems. When not physically possible to maintain the shield throughout the entire electrical circuit, as a minimum the wiring shall be twisted and shielded from the system initiator to the point of the first short circuit condition. This requirement is applicable both before and after installation of SAFE/ARM type connectors. The use of single wire firing lines, with the shield as the return, is prohibited.

5.3.4.4.1.4 Shielding shall provide a minimum of 20 dB safety margin below the minimum rated function current of the system initiator (max NO-FIRE current for EED's) and provide a minimum of 85% optical coverage. (A solid shield rather than a mesh would provide 100% optical coverage).

5.3.4.4.1.5 Shielding shall be continuous and terminated to the shell of connectors and/or components. The shield shall be electrically joined to the shell of the connector/component around the full 360 degrees of the shield. The shell of connectors/components shall provide attenuation at least equal to that of the shield.

5.3.4.4.1.6 The electrical circuit to which the system EED is connected shall be isolated from vehicle ground by no less than 10K ohms.

5.3.4.4.1.7 All circuits shall be designed with a minimum of two independent safety devices. Any time personnel are exposed to a hazardous system, a minimum of two independent safety devices are required to be in place.

5.3.4.4.1.8 The system EED shall be provided with an electrical short until its programmed actuation unless an exemption is granted by the Head, Safety and Quality Assurance Engineering Branch. This requirement does not negate the use of solid state switches.

5.3.4.4.1.9 Any electrical relay or switch, which is electrically adjacent to the system initiator (either in the power or return leg of the electrical circuit), shall not have voltage applied to the switching coil (or the enable/disable circuit for solid state relays/switches) until the programmed initiation event.

5.3.4.4.2 Charged ("Hot") batteries may be installed into Category "A" circuits only if at least one of the following design approaches is utilized. Otherwise, the battery shall be charged at the latest feasible point in the countdown process with no personnel in the defined danger area.

5.3.4.4.2.1 The system is designed with a mechanical or electromechanical SAFE/ARM device which shall adequately contain the output of the system or its initiator when in the SAFE position.

5.3.4.4.2.2 The system is designed to meet Capacitive Discharge Ignition (CDI) circuit criteria as defined in Paragraph 5.3.4.4.4.

5.3.4.4.2.3 The system is designed to meet Man-Rated circuit requirements as defined in Paragraph 5.3.4.4.5.

5.3.4.4.2.4 The system is designed to meet Exploding Bridgewire (EBW) circuit requirements as defined in Paragraph 5.3.4.4.6.

5.3.4.4.3 Category "A" circuits shall be designed such that the following operations can be accomplished:

5.3.4.4.3.1 Mechanical installation and electrical connection of the system initiators can be performed at the latest possible time in the assembly process, consistent with other assembly operations.

5.3.4.4.3.2 Prior to connecting an EED to its electrical circuit, it shall be shorted, shielded, and grounded. Connect EEDs to chassis ground and the chassis to a single-point earth ground.

5.3.4.4.3.3 Prior to connecting system initiators to their electrical circuit, voltage checks shall be made between each leg of the circuit and from each leg to ground to ensure no voltage is present.

5.3.4.4.4 Capacitive Discharge Ignition (CDI) circuit design requirements

CDI circuit shall meet the requirements in paragraph in 5.3.4.4 through 5.3.4.4.3.3.3 and the following additional requirements.

5.3.4.4.4.1 The charging battery shall be current limited such that it shall not exceed 10% of the minimum rated function current of the system initiator (max NO-FIRE current for EED's).

5.3.4.4.4.2 The firing capacitor shall be provided with an electrical short (when the circuit is in the SAFE condition) and a means of remotely monitoring capacitor voltage. Whenever personnel are exposed to the system, the firing capacitor shall be shorted.

5.3.4.4.4.3 There shall be a minimum of two independent open switches between the power source and the system initiator.

5.3.4.4.5 Man-Rated Circuit Design Requirements

Man-Rated circuit shall meet the requirements in paragraph in 5.3.4.4 through 5.3.4.4.3.3.3 and the following additional requirements.

5.3.4.4.5.1 The system initiator shall be both physically and electrically isolated from the power source by a minimum of three independent safety devices. This requirement is applicable both before and after installation of SAFE/ARM type connectors. Electromechanical out-of-line SAFE/ARM devices which can be both Armed and Disarmed remotely shall be counted as two safety devices.

5.3.4.4.5.2 The system initiator shall be electrically isolated by switches in both the power and return legs. The wiring between the initiator and the switch in both the power and return legs shall have the following additional features:

5.3.4.4.5.2.1 The wiring shall be in a separate cable which is twisted, shielded, double insulated, and independent of all other systems. Shielded wiring shall meet the requirements of 5.3.4.4.1.4 and 5.3.4.4.1.5.

5.3.4.4.5.2.2 Protection by use of physical barriers or by physical location of components shall be employed such that short circuits to other power systems are impossible, even assuming loose or broken wires.

5.3.4.4.5.3 A Failure Mode and Effects Analysis (FMEA) shall be performed to ensure a minimum of three independent failures are required for a premature actuation to occur. The detail level of the FMEA shall be established by the Head, GFSS and shall be based on factors such as type of system, system design, and level of hazard.

5.3.4.4.5.4 A Quality Assurance program shall verify compliance with all requirements and certify the "as built" configuration.

5.3.4.4.6 Exploding Bridgewire (EBW) Circuit Design Requirements

5.3.4.4.6.1 A means of continuously monitoring the firing capacitor voltage shall be provided.

5.3.4.4.6.2 Two separate electrical paths to discharge the firing capacitor shall be provided. This can be provided either through the EBW circuit or through the Ground Support Equipment.

5.3.4.4.6.3 A positive means of interrupting the capacitor charging circuit shall be provided.

5.3.4.4.6.4 A positive means of interrupting the EBW triggering circuit shall be provided.

5.3.4.4.6.5 A time delay of several seconds between application of the arming signal and application of the trigger signal for the EBW to fire shall be provided.

5.3.5 Ground Support Equipment (GSE)

5.3.5.1 The design of GSE used to make measurements on or provide control of hazardous devices, systems, or circuits shall be approved by the Head, Safety and Quality Assurance Engineering Branch, or his designee.

5.3.5.2 All electrical meters or test equipment used to make measurements of hazardous systems shall be current limited to 50 ma**.**

5.3.5.3 All GSE used in, or to obtain measurements of, hazardous systems (electrical meters, pressure gages, slings, scales, etc.) shall be calibrated/certified and may not be used beyond the certification period. Certifications shall be performed at GSFC/WFF unless approval for certifications performed at other sites/facilities is obtained from the Head, Safety and Quality Assurance Engineering Branch.

5.3.5.4 All meters which are used to measure resistance of ordnance devices are required to be tested for proper operation immediately prior to starting the procedure.

5.3.5.5 All lifting devices, fixtures, and equipment shall conform to the standards and regulations of NSS/GO-1740.9 and GMI 1710.6 (Reference e and u).

5.3.5.6 Electrically operated GSE (vacuum systems, heaters, pumps, etc.) used on Category "A" systems shall meet the following design criteria and restrictions.

5.3.5.6.1 All GSE shall be designed such that the system can be remotely switched ON/OFF.

5.3.5.6.2 No personnel shall be permitted to be within Danger Areas defined in safety plans while power is being supplied to its GSE.

5.3.5.6.3 GSE shall be switched OFF prior to system arming operations. After arming operations are complete, the GSE may be switched ON provided items 5.3.5.5.1 and 5.3.5.5.2 above are satisfied.

5.3.5.6.4 The design of GSE should consider the impact of the above restrictions on operations. Fly-away connectors should be used to permit system operation late in the countdown process. For vacuum systems, a remotely operated valve is recommended to maintain vacuum integrity when power is switched OFF.

5.3.6 Electrostatic Discharge (ESD) Hazards

5.3.6.1 Precautions shall be taken to eliminate or reduce the risk of electrostatic discharge during potentially hazardous operations. The method used to eliminate or reduce static electricity is to provide an electrically continuous path to ground. All conductive objects (including personnel) shall be electrically connected to a common ground.

5.3.6.2 Grounding straps shall be used to bridge locations where electrical continuity may be broken by grease, paint, or rust. Equipment in contact with conductive floors or table tops is not considered adequately grounded.

5.3.6.3 Wire used as a static ground conductor shall be large enough to withstand mechanical damage and shall not be less than American Wire Gauge (AWG) No. 8 or a braided cable of equal conductivity.

5.3.6.4 Connection of static ground conductor shall be made to certified grounding points. Grounding point certification shall be performed semiannually.

5.3.6.5 When performing potentially hazardous operations on electrostatic sensitive systems, personnel shall comply with the following:

5.3.6.5.1 Wrist straps shall be worn and connected to a certified ground when handling EED's or when working on exposed rocket motor grain.

5.3.6.5.2 Outer garments (e.g. labcoats or overalls) shall be worn that dissipate static charges. Under special circumstances, the use of static dissipative outer garments may be waived by the Head, Ground and Flight Safety Section, or his designee.

5.3.6.5.3 Personnel are required to touch the ground system upon entering an ordnance work area. This grounding requirement applies even when wearing protective clothing.

5.3.6.5.4 Ionization - Ionizers may be used for static neutralization in ordnance work areas, only with specific approval from the Head, Safety and Quality Assurance Engineering Branch. Use of these instruments shall be allowed only when other means of static neutralization are not effective and may never be used directly on ordnance items.

5.3.7 Electrical Storm Criteria

5.3.7.1 When an electrical storm is detected within 15 nautical miles or the potential for an electrical storm is forecast within 10 nautical miles of potentially hazardous work areas, a warning shall be issued to bring operations to an appropriate stopping point.

5.3.7.2 When the storm is detected within 10 nautical miles or the potential for an electrical storm is forecast within 5 nautical miles of potentially hazardous work areas, the area shall be evacuated regardless of the status of the operations.

5.3.7.3 If a warning system is not available to determine the approach of an electrical storm, the potentially hazardous work area shall be cleared upon hearing thunder or observing weather conditions, which have the potential of producing electrical storms.

5.3.8 Radiation Systems

Radiation shall be adequately controlled during all operational phases to assure the protection of personnel, facilities and equipment and compliance with applicable federal, state, and NASA regulations. Such sources include radio-frequency/microwave emitters, radioactive materials, x-ray devices, lasers, and optical emitters.

5.3.8.1 Non-ionizing Radio Frequency (RF) Radiation Controls

5.3.8.1.1 RF-radiation sources used at WFF shall be approved by the Wallops Frequency Utilization Management Working Group.

5.3.8.1.2 All operations involving the use of RF transmitters shall be coordinated through the Range Control Center (5.4.2.2) and conform to the standards and regulations specified in ANSI C95.1-1982 (Reference f) and GHB 1860.2 (Reference g).

5.3.8.1.3 Mission-specific descriptions of RF transmitters and restrictions shall be provided in the Ground Safety Plans/Data Packages.

5.3.8.1.4 RF radiation into areas where ordnance operations are conducted shall be controlled to assure insufficient energy exists to cause premature initiation of ordnance.

5.3.8.1.5 RF avoidance times shall be established in operational plans for all transmitters capable of producing a potential hazard to any ordnance operation. RF avoidance is defined as no radiation within ±20° (azimuth and elevation) of the ordnance site. Any deviation of this requirement shall be approved by the Head, Ground and Flight Safety Section, or his designee.

5.3.8.1.6 Personnel and ordnance hazard distances for all transmitters shall be jointly defined by the Safety and Health Branch and the Ground and Flight Safety Section.

5.3.8.2 Ionizing Radiation Controls

5.3.8.2.1 All operations involving the use of radioactive sources shall conform to the standards and regulations of the Nuclear Regulatory Commission, 10 CFR (Reference h), GHB 1860.1B (Reference i), and regulations of the host range.

5.3.8.2.2 The range user is responsible for obtaining all licenses for radioactive materials.

5.3.8.2.3 Procedures for the use, handling, and storage of radioactive sources shall be designed to minimize the exposure of personnel.

5.3.8.2.4 Range users shall identify all radioactive sources and provide Material Safety Data Sheets (MSDS) for each radioactive source to be used. This includes calibration sources as well as test sources.

5.3.8.2.5 Range users shall provide GSFC/WFF with detailed operating procedures for use, handling, and storage of non-exempt radioactive sources (as defined in 10 CFR, Reference h) while on the range. Specific data requirements are listed in Section 8.0 and GHB 1860.1B (Reference i).

5.3.8.2.6 Ionizing radiation sources shall be removed from the range by the range user at the end of the program.

5.3.8.3 Laser Hazards Control

5.3.8.3.1 All operations involving the use of lasers shall comply with the standards and regulations of ANSI Z136.1-1986 (Reference j) and GHB 1860.3 (Reference k).

5.3.8.3.2 Access and laser illumination levels shall be controlled to insure that no personnel are present within the ocular hazard area of the laser unless suitable protection is provided.

5.3.8.3.3 Range users shall provide WFF with characteristics and detailed operating procedures for controlling and use of lasers.

5.3.9 Chemical Hazards

A chemical hazard is posed by any material (solid, liquid, or gas) that presents a health risk or physical hazard to personnel, property, or the environment.

5.3.9.1 Procedures addressing use, clean-up, and spill response of hazardous materials shall be developed. These procedures shall be reviewed and approved by GFSS and the Safety, Environmental, and Security Office .

5.3.9.2 The WFF Safety, Environmental, and Security Office shall be notified of hazardous materials requiring disposal.

5.3.9.3 Material Safety Data Sheets (MSDS) shall be available during all operations involving hazardous materials. Hazardous material handlers, cognizant Ground and Flight Safety Section personnel, and Safety and Health Branch personnel, shall have knowledge of material compatibilities, physical and health hazards, and first aid techniques relevant to the hazardous materials in question.

5.3.9.4 The following measures shall be employed if there exists a possibility of a hazardous chemical spill.

5.3.9.4.1 Spill potentials shall be evaluated on a case-by-case basis and potential hazard areas shall be defined in a Ground Safety Plan.

5.3.9.4.2 A means to minimize the surface area of potential spills by diking, design, or other methods shall be employed.

5.3.9.5 The following measures shall be used to address potential leaks of hazardous fluids or gases:

5.3.9.5.1 All GSE electrical hardware used in areas where flammable/combustible chemicals may be present in local vapor concentrations greater than 25% of the Lower Explosive Limit (LEL) shall be rated "explosion proof" in accordance with Article 500 of the National Electrical Code (Reference l), or, if this is not possible, (1) the flammable/combustible chemical concentrations shall be continuously monitored and (2) a master switch capable of deactivating "non-explosion proof" electrical hardware shall be conveniently located in the work area.

5.3.9.5.2 Areas of hazardous fluid or gas transfer and storage shall be monitored by approved equipment to detect toxic and flammable concentrations.

5.3.9.5.3 Chemical transfer operations which are hazardous shall not occur without prior approval of and supervision by the Operations Safety Supervisor.

5.3.10 Hazardous Chemical System Hardware

Hazardous chemical hardware shall be designed to prevent hazardous chemicals from spilling or leaking, and, thereby, injuring personnel, property, or contaminating the environment.

5.3.10.1 Hazardous chemical systems which release caustic, toxic, or reactive chemicals shall be designed such that the flow path contains two independent safeties to prevent an inadvertent release.

5.3.10.2 Components of hazardous chemical systems shall feature redundant mechanical or welded seals at all fittings to prevent the inadvertent flow or release of caustic, toxic, and/or reactive chemicals.

5.3.10.3 Materials selected for use in hazardous chemical systems shall be compatible with the hazardous chemical used. This should include compatibility under operating pressure, shock, vibration, reactivity and temperature conditions. Analyses on items such as stress corrosion or adiabatic compressibility shall be performed when applicable. Specific properties of propellants may be determined by reference to standard industry manuals such as the CPIA Publication 394 (Reference m).

5.3.10.4 Bi-propellant systems that incorporate both a fuel and an oxidizer shall be designed such that a malfunction of either the oxidizer or fuel subsystems cannot result in mixing. In general, all hazardous chemical systems shall be designed to preclude the inadvertent mixing of hazardous chemicals, especially in cases where chemical reactions could have catastrophic consequences.

5.3.10.5 Mono-propellant systems that feature a fuel and a catalytic bed shall incorporate at least two independent safeties in the flow path to prevent inadvertent fuel contact with the catalytic bed.

5.3.10.6 The need for remote status monitoring of the system and/or its components shall be evaluated by the Ground and Flight Safety Section on a case by case basis.

5.3.10.7 Hardware (tanks, transfer lines, etc.) shall conform to applicable ASME and DoT specifications.

5.3.11 Man-Rated Liquid Propulsion Systems

5.3.11.1 General Requirements

5.3.11.1.1 A man-rated propulsion system shall be employed when the following two conditions exist: 1) a leak or spill of the propellant poses a catastrophic hazard; and, 2) the propulsion system may be placed in a condition whereby spill response is not possible.

5.3.11.1.2 The propulsion system's primary leak path (i.e. from the propellant tank through the thrusters) shall contain a minimum of three mechanically independent safeties in series. If the mechanical safeties are electrically controlled, the electrical controls shall be independent of each other. A pyrotechnically actuated isolation valve with two fault tolerant electrical safeties immediately downstream from the liquid propellant tank shall be considered equivalent to two flow control safeties.

5.3.11.1.3 Secondary leak paths (i.e. through or around wetted fittings to the ambient environment) shall contain a minimum of two safeties in series to prevent a catastrophic leak/spill past a wetted fitting. A fitting that has been sealed by welding shall be considered equivalent to two mechanical seals. Metal-to-metal fittings (e.g. Swagelok and AN fittings) shall be considered equivalent to two safeties.

5.3.11.1.4 Prior to a launch, flow control devices within the liquid propulsion system shall not be operated under those condition(s) that preclude spill/leak response.

5.3.11.2 Electrical Hardware

5.3.11.2.1 The electrical circuit(s) that operate the liquid propellant flow control devices shall be man-rated (i.e. two fault tolerant). At least two of the three electrical inhibits shall be remotely monitored when conditions preclude spill/leak response.

5.3.11.2.2 Electrical circuit(s) that operate components whose failure may cause the liquid propellant to catastrophically overheat (thus causing either propellant decomposition or propellant tank overpressurization) shall be man-rated.

5.3.11.3 Pressure Relief

5.3.11.3.1 The pressurant side of hazardous liquid propulsion system shall be either electrically and mechanically single fault tolerant to exceed system Maximum Operating Pressure (MOP), or shall be equipped with a pressure relief device. The relief device shall be set and certified by tagging at 10% above system MOP.

5.3.11.3.2 The system shall be mechanically and electrically two fault tolerant to exceeding system burst pressure.

5.3.11.4 Seals

5.3.11.4.1 A quality control program shall verify that all system fittings and seals are properly installed and have leak integrity.

5.3.11.4.1.1 Welds shall be made only by certified welders.

5.3.11.4.1.2 Lot and batch short-term compatibility testing shall be performed for elastomeric seals to assure material compatibility.

5.3.11.4.1.3 Positive means such as periodic leak checking, manufacturer's gaging techniques, and/or other measures shall assure that metal-to-metal seals (e.g. Swagelok and AN fittings) do not lose leak integrity by improper installation or loosening ("backing-off") during transport or handling.

5.3.11.4.2 The optimum design for redundant mechanical seals is to seat one at the fitting face and the other radially to seal the fitting.

5.3.11.5 Monitoring

5.3.11.5.1 An instrument that continuously monitors for airborne concentrations of the toxic liquid propellant shall be used during ground operations.

5.3.11.5.2 During those operations that cannot be considered ground operations, but still place personnel under the jurisdiction of Wallops Flight Facility at risk (e.g. captive flight), and when spill/leak response is not possible, system pressure monitoring shall be required as a minimum effort.

5.3.11.5.3 All personnel who shall work in the proximity of the fueled liquid propulsion system shall wear passive dosimeters to monitor possible personnel exposures.

5.3.12 Pressure Systems

5.3.12.1 All ground support pressure systems shall meet ASME Boiler and Pressure Vessel Codes (Reference n) or GMI 1710.4 (Reference o).

5.3.12.2 Unrestricted access shall be granted for all airborne pressure systems (gaseous and liquid) that are certified to the ASME Boiler and Pressure Vessel Codes (Reference n) or have stored energy levels less than 100k Joules (75k ft-lbs) and operating pressure less than 150 psi for gases and 1500 psi for liquids. Systems that contain fluids that are toxic and/or flammable shall also meet requirements of sections 5.3.9, 5.3.10, or 5.3.11 as applicable.

5.3.12.3 If the airborne pressure system does not meet 5.3.12.2, then it shall be remotely pressurized for any of the following:

5.3.12.3.1 During the initial pressurization of the system, following system assembly or refurbishment. Initial pressurization shall certify system integrity up to 25% of Design Burst Pressure.

5.3.12.3.2 After the pressure system has been exposed to excessive vibration or shock or it has been transported in an unknown environment.

5.3.12.3.3 During pressurization above 25% of the Design Burst Pressure.

5.3.12.4 All airborne systems shall comply with the design requirements of MIL STD 1522A (Reference p).

5.3.12.5 Restricted access is permitted for airborne pressure systems designed to the requirements of MIL-STD-1522A.

5.3.12.5.1 Restricted access shall be permitted when the system steady state pressure is less than the MAWP.

5.3.12.6 Whenever the system pressure exceeds the MAWP, personnel shall be separated from the pressure vessel(s) by a barrier designed to protect against blast and fragmentation, or personnel shall be outside the pressure vessel danger area.

5.3.12.6.1 The pressure vessel danger area shall be defined in the Ground Safety Plan/Data Package for that mission.

5.3.12.7 Flight pressure systems shall be re-certified by inspection, testing, or analysis prior to being reflown. The method of recertification shall be documented in an approved plan for each pressure vessel.

5.3.12.8 If a pressure relief device is employed, it shall be set and certified by tagging at no greater than 10% above MOP. This pressure level is defined as the Maximum Design Operating Pressure (MDOP), and may not exceed the proof pressure.

5.3.13 Personal Protective Equipment

Safety glasses, safety shoes, hard hats, arctic clothing, shop coats, etc., are required to be used by GSFC/WFF employees, contractors, experimenters, and range users when exposed to certain hazardous conditions.

5.3.13.1 All personnel shall wear static-dissipating clothing in processing areas for ordnance or other hazardous systems which are susceptible to electrostatic discharge. Ordnance handlers shall not wear static producing clothing (i.e. wool, rayon, nylon, polyester, etc.).

5.3.13.2 During operations involving EED or exposed grain, all personnel are required to wear approved grounded wrist-straps. Approved leg-stats may be used, in place of wrist-straps, for specific operations approved by the Head, Safety and Quality Assurance Engineering Branch.

5.3.13.3 Safety glasses or face shields are required for operations that a ocular hazard may exists.

5.3.13.4 Hard hats are required for operations where personnel work on multiple levels.

5.3.13.5 Operations involving chemicals that pose a health risk require that personnel wear protective equipment (identified on a case-by-case basis in the specific operational procedure) that shall provide respiratory and/or full body protection during:

5.3.13.5.1 Connecting or disconnecting wet lines or contaminated (neither purged nor flushed) dry lines.

5.3.13.5.2 Sampling operations.

5.3.13.5.3 Flow/transfer operations.

5.3.13.5.4 Operations where there is only one safety device preventing a chemical spill.

5.3.13.5.5 Chemical spill cleanup.

5.3.13.6 Personnel working with cryogenic liquids shall wear proper protective equipment including: hand and foot protection, face protection, and appropriate outer garments.

5.4 Operational Security, Controls, and Procedures

The GSFC/WFF has established operational safety controls with which all persons at GSFC/WFF shall comply. These controls include:

5.4.1 Security

5.4.1.1 Badges - Special badges are required of all personnel for admission to Wallops Island and other restricted areas. Workshops, launch areas and facilities are restricted and placarded to identify the presence of hazardous materials/operations and to warn against unauthorized entry. Admittance to such restricted areas is limited to personnel displaying the proper badges.

5.4.1.1.1 Orange - identifies essential, experienced personnel and permits the wearer to be in areas where potentially hazardous operations are occurring. Orange badges are normally issued to GSFC/WFF-based personnel working in the proximity of hazardous systems.

5.4.1.1.2 Green - identifies visiting, mission-specific essential personnel who, with the Operations Safety Supervisor's permission, are permitted in areas where potentially hazardous operations (of their mission) are occurring. When multiple potentially hazardous operations are occurring, green badges shall be coded to indicate the wearers' operations area(s). Badge coding shall be coordinated and assigned by the Range Support Manager.

5.4.1.1.3 Yellow - identifies personnel not associated with potentially hazardous operations, e.g. Radar, Navy, custodial, project administrative, etc. Wearer is permitted entrance only to areas of non-hazardous (Category "B") operations. When any system is in a hazardous (Category "A") condition, wearers of yellow badges shall vacate the area or be escorted by a supervisor who has an orange badge.

5.4.1.2 Danger Area Access - Access into operational danger areas at GSFC/WFF is controlled by the Danger Area Warning System and roadblocks. Admittance into the Danger Area is always controlled by the Operations Safety Supervisor.

5.4.1.2.1 Danger Area Warning System - GSFC/WFF Danger Area warning systems involve the use of lights, sirens, signs, and/or roadblocks to alert personnel of the potential hazards present in certain areas and/or to prevent personnel from entering these areas. Under no circumstances shall personnel pass through an active danger area warning system without first obtaining permission from the Operations Safety Supervisor or his designee.

5.4.1.2.2 Launch Pad Warning System - GSFC/WFF Launch Pad Warning Systems involve the use of lights and exterior public address systems to advise personnel during Danger Time I, Danger Time II, Caution Time, and All Clear status changes, or other hazardous periods. Hazard warning lights are visible from all angles of approach. These systems are operated to indicate the following conditions:

5.4.1.2.2.1 Danger Time II - Flashing red light at launch pad and Prelaunch Roadblock. No personnel are permitted access to the pad.

5.4.1.2.2.2	Danger Time I	-	Flashing amber light at pad. Only active/essential personnel performing specific tasks are permitted access to the pad.
5.4.1.2.2.3	Caution Time	-	Flashing amber light at pad; no light at Prelaunch Roadblock. Only essential personnel with Operations Safety Supervisor's permission are permitted access to the pad.
5.4.1.2.2.4	All Clear	-	No warning lights at pad or Prelaunch Roadblock. All personnel are permitted access to the pad.

5.4.1.2.3 Launch Pad Roadblocks - In addition to the warning systems, manned and/or unmanned roadblocks are established at various places and times. The unmanned roadblocks are equipped with flashing red lights indicating Prelaunch Danger Area status. Unmanned roadblocks shall be equipped with communications equipment and a sign directing action. Under no circumstances shall personnel pass through a roadblock without permission from the Operations Safety Supervisor or his designee.

5.4.1.3 Explosives Signs and/or Symbols - Based on procedures of the U. N. document (Reference q) and DoD 6055.9 STD (Reference d), the GSFC/WFF utilizes four symbols to denote different classes of ordnance. These symbols are prominently displayed on International Orange signs at each magazine and refer to the most hazardous material stored within.

5.4.1.3.1 Class 1, Division 1: an octagonal-shaped sign displaying the numeral "1" in the center denotes the presence of DoD Hazard Class/Division 1.1 explosives, which present a blast and fragmentation hazard and can be expected to mass detonate when exposed to fire.

5.4.1.3.2 Class 1, Division 2: an X-shaped sign displaying the numeral "2" in the center denotes the presence of DoD Hazard Class/Division 1.2 explosives, which present a fragmentation hazard.

5.4.1.3.3 Class 1, Division 3: an inverted triangular sign displaying the numeral "3" in the center, denotes the presence of DoD Hazard Class/Division 1.3 explosives, which present a mass fire hazard.

5.4.1.3.4 Class 1, Division 4, on a diamond-shaped sign displaying the numeral "4" in the center, denotes the presence of DoD Hazard Class/Division 1.4 explosives, which present a moderate fire hazard.

5.4.1.4 RF Radiation Controls

5.4.1.4.1 Operational Restrictions - All RF emitters used at GSFC/WFF shall be periodically analyzed to determine whether or not they pose a potential hazard to personnel or ordnance. When a potential hazard exists, operational restrictions and/or controls shall be established to protect personnel and/or ordnance systems.

5.4.1.4.2 Barricades/Signs - In areas where RF hazards to personnel exist, signs and/or barricades shall be erected to prevent personnel from entering the potential hazard area.

5.4.1.4.3 Warning Lights - On high power RF emitters such as Radar Systems, red and blue warning lights shall be utilized to warn personnel of the potential RF hazard. A red flashing light shall be illuminated whenever power is supplied to the system. A blue flashing light shall be illuminated whenever the emitter is radiating.

5.4.2 Operational Controls

For all potentially hazardous operations at GSFC/WFF, the Test Director, Assistant Test Director, Range Safety Officer, and Operations Safety Supervisor exercise control over all personnel associated with the operation. For off-range operations, Section 2.5 establishes the hierarchy for operational control.

5.4.2.1 All NASA personnel, NASA contractors, experimenters, range users, and tenants are responsible for:

5.4.2.1.1 Adhering to the requirements established in this document.

5.4.2.1.2 Adhering to the directions issued by the Test Director, Range Safety Officer, and/or Operations Safety Supervisor.

5.4.2.1.3 Reviewing vehicle and payload operations with the Operations Safety Supervisor.

5.4.2.1.4 Obtaining permission from the Operations Safety Supervisor before conducting any operation in assembly, test, or launch areas.

5.4.2.1.5 Identifying active essential personnel for each operation to assure maximum personnel limits are not exceeded.

5.4.2.2 All RF radiation on GSFC/WFF is controlled through the Range Control Center, to assure that RF limits (5.3.8.1) are not exceeded and to preclude possible interference with other transmitters. Range users shall obtain permission through the Operations Safety Supervisor before any RF transmitters can be switched ON.

5.4.2.3 The Ground Safety Plan/Data Package defines Danger Area clearance requirements and personnel restrictions for all potentially hazardous operations. All personnel at GSFC/WFF are responsible for complying with these restrictions.

5.4.2.4 All personnel performing potentially hazardous operations (explosives handling, chemical transfer, etc.) shall be trained and experienced. These personnel are required to be certified or directly supervised by certified personnel when performing these operations. GSFC/WFF will approve all personnel certifications or may approve certifications established by user programs. Range user**s** shall provide documentation that supports training, experience, or certification of their personnel.

5.4.3 Operational Procedures

5.4.3.1 Range users are responsible for submitting to GSFC/WFF comprehensive handling, assembly, and/or checkout procedures for all hazardous systems for review and approval. Operations shall not be conducted until these assembly and test procedures have been approved by the Ground and Flight Safety Section, the Launch Vehicles Branch, and the Reliability & Quality Assurance Officer.

5.4.3.2 Under no circumstances shall a potentially hazardous operation begin without prior approval from the Operations Safety Supervisor.

5.4.3.3 GSFC/WFF requires that no unrelated tasks be conducted simultaneously, within overlapping Danger Areas, on hazardous systems. It is the responsibility of all supervisory personnel to prepare work schedules to comply with this requirement.

5.4.3.4 Instruments used to measure the resistance of EED's shall (a) contain a certification sticker and (b) be checked, immediately prior to use, to assure the short circuit current is less than 50mA.

5.4.3.5 Range users shall obtain permission from the Operations Safety Supervisor prior to making a power switch on any vehicle/payload or ground support system.

5.4.3.6 Emergency Procedures - Prior to conducting an operation, GSFC/WFF shall establish emergency procedures and an emergency response team in the event of launch abort or recovery. Range Users shall identify personnel as required by the GSFC/WFF to participate on any emergency or recovery team.

5.4.3.7 For off-range operations, permission to perform the above operations shall be granted by the hierarchy defined in Section 2.5.

6.0 FLIGHT SAFETY

6.1 Policies

6.1.1 The flight safety goal is to protect the public, range participants, and property from the risk created by conducting potentially hazardous operations at GSFC/WFF and to prevent mishaps that would result in embarrassment to NASA or the United States Government. Although these risks can never be completely eliminated, the flight should be carefully planned to minimize the risks involved while enhancing the probability for attaining the mission objectives.

6.1.2 The GSFC/WFF is responsible for flight safety until all flight components have reached impact or have achieved orbital insertion. A flight safety program shall be implemented to protect the public and participating personnel for all GSFC/WFF launch operations and operations conducted by GSFC/WFF at mobile ranges established at remote sites. For operations conducted at other established ranges, GSFC/WFF is responsible for assuring that NASA personnel, contractors, and experimenters are not exposed to risk greater than the acceptable risks established by this document.

6.1.3 Flight safety is generally associated with the containment of vehicle flight within approved operational areas and impacts (spent stages, payloads, balloons, payload/parachutes, etc.) within planned impact areas. Since the entire set of variables (vehicle aerodynamic/ballistic capabilities; azimuth and elevation angles; wind, air and sea traffic, and proposed impact areas) are unique, flight safety analysis shall be performed for each mission. Vehicle design, reliability, performance, and error predictions for each flight case shall be reviewed by the Ground and Flight Safety Section (GFSS) personnel to certify the flight-worthiness of the launch vehicle.

6.1.4 Flight safety data shall be prepared by the GFSS of the GSFC/WFF prior to any launch operations where GSFC/WFF has flight safety responsibilities. This data shall be published in a Flight Safety Plan and shall describe the proposed vehicle flight and the means to contain it safely. For operations at other established ranges, any special flight safety restrictions or requirements shall be documented in a Flight Safety Data Package for that operation. For National Scientific Balloon Facility (NSBF) balloon operations, any special flight safety restrictions or requirements shall be documented in a program Safety Analysis Report (SAR) or an individual mission Risk Analysis document.

6.1.5 The Ground and Flight Safety Section shall certify the flight worthiness of all rockets, missiles, drones, and other similar vehicles.

6.1.6 Flight Safety for aircraft operations shall assure that public exposure to risk does not exceed the limits defined in Section 6.2.

6.2 Risk Criteria

All mission activities shall be conducted such that the risk shall not exceed the following unless a complete analysis and review are conducted and results are documented in an approved Safety Analysis Report. Risk controls for protecting land masses shall be implemented by establishing casualty expectation limits and risk controls for protecting ships and aircraft shall be implemented by establishing maximum hit probabilities.

6.2.1 Public Risk

6.2.1.1 The casualty expectation, for all mission activities, shall be less than 1×10^{-6}.

6.2.1.2 The probability of hitting a ship shall be less than 1×10^{-5} for each impact area.

6.2.1.3 The probability of hitting an aircraft shall be less than 1×10^{-7} for each impact area. The minimum aircraft hazard area shall be 1.2 sigma.

6.2.1.4 The probability of spent stages or other vehicle hardware impacting in unapproved areas shall be a factor in determining mission approval.

6.2.2 Participating Personnel Risk

6.2.2.1 The casualty expectation, for all mission activities, shall be less than 1×10^{-5}.

6.2.2.2 The probability of hitting a ship shall be less than 1×10^{-5} for each impact area.

6.2.2.3 The probability of hitting an aircraft shall be less than 1×10^{-7} for each impact area. The minimum aircraft hazard area shall be 1.2 sigma.

6.2.3 Exemptions

A mission where the risk exceeds one or more of the above criteria may be conducted provided:

6.2.3.1 Formal government or private agreements allow the use of the area for flight and impact, or

6.2.3.2 A Safety Analysis Report documenting the mission risk level is prepared and approved.

6.3 Flight Termination

6.3.1 Flight termination systems are required to meet design features as specified in the Range Commanders Council Document "Flight Termination Systems Commonality Standard", Standard 319-92 (Reference r).

6.3.2 Flight termination may consist of command destruct, thrust termination, auto destruct, recovery initiation, command fire system, or command no-fire systems.

6.3.3 Requirements for Rockets, Missiles, Drones, and other similar vehicles

6.3.3.1 A flight termination system is required in every stage (each motor) of a launch vehicle, unless it is shown that the maximum range of the vehicle is less than the range to all protected areas, or a risk analysis shows that all of the mission risk criteria specified in Section 6.2 are satisfied, or the vehicle is inherently safe.

6.3.3.2 An operation is considered inherently safe if the predicted flight is based solely on launch and dispersion parameters and known system errors. The Head, Safety and Quality Assurance Engineering Branch, or his designee, is responsible for determining if an operation is inherently safe and for approving the type and design of the flight termination system.

6.3.3.3 Operations are considered inherently safe if all of the following conditions are true:

6.3.3.3.1 The vehicle does not contain a guidance or control system;

6.3.3.3.2 The vehicle can be accurately wind weighted to provide an acceptable impact location;

6.3.3.3.3 Launch limits, as stated in section 6.4.1.4.1 and 6.4.1.4.2, are met.

6.3.4 Requirements for Balloons

6.3.4.1 A flight termination system is required, unless the maximum weight and weight per surface area criteria of Federal Aviation Regulations part 101 (Reference s) are satisfied.

6.3.4.2 If a flight termination system is employed, a parachute recovery system is also required to reduce the payload terminal velocity to less than 25 feet per second (for land impacts).

6.4 Operational Procedures

6.4.1 Rocket, Missile, Drone, and other similar vehicles

6.4.1.1 Hazard Areas

6.4.1.1.1 Hazard areas are developed by probabilistic calculations or by maximum range capability.

6.4.1.1.2 Aircraft hazard areas shall be developed for all operations. For vehicles whose computed aircraft hazard area radius is less than 1.2 sigma dispersion, an aircraft hazard area radius equal to 1.2 sigma dispersion shall be implemented.

6.4.1.1.3 DoD ship clearance hazard areas shall be developed for all impacts in the Virginia Capes (VACAPES).

6.4.1.1.4 Ship impact probability calculations shall be performed for all operations where applicable.

6.4.1.2 Range Clearance

6.4.1.2.1 GSFC/WFF shall coordinate its operations with the Federal Aviation Administration (FAA), the U. S. Navy, and other organizations, as required, to clear potential hazard areas.

6.4.1.2.2 All impacts within the VACAPES operating areas require clearance from the Fleet Area Control and Surveillance Facility (FACSFAC) prior to launch. Any part of the ship hazard area that is within VACAPE shall be surveyed for ships.

6.4.1.2.3 Clearance with the FAA is required for any aircraft hazard area that extends beyond the VACAPES operating areas.

6.4.1.2.4 NOTAMS and NOTMARS shall be issued at least twenty four hours prior to launch.

6.4.1.3 Collision Aviodance (COLA)

6.4.1.3.1 GSFC/WFF shall insure that all manned spacecraft and high valued satellites (as required) are protected from collision with sounding rocket and ELV motors, payloads, or other expended items.

6.4.1.3.2 Manned spacecraft shall be protected with a minimum separation distance of 200KM.

6.4.1.3.3 Unmanned satellites shall be protected with a minimum separation distance of 50KM.

6.4.1.4 Wind Weighting

6.4.1.4.1 All unguided vehicles shall be wind weighted, except as noted in 6.4.1.3.2. An unguided portion of flight for guided vehicles shall also be wind weighted.

6.4.1.4.2 Low performance vehicles (i.e. test rockets) may be launched without being wind weighted, provided the effective elevation is 80° or less and all other safety criteria are met.

6.4.1.4.3 The operational wind weighting system shall produce solutions with errors no greater than those used to determine vehicle dispersion and potential hazard areas.

6.4.1.5 Ground Launched Vehicles Without Flight Termination Systems

6.4.1.5.1 The maximum effective launcher elevation setting is 85°.

6.4.1.5.2 The maximum wind corrected launcher elevation setting is 86°.

6.4.1.5.3 For unproven launch vehicles, the maximum effective launcher elevation setting is 80°. The effective azimuth shall be chosen such that the geographical advantages of the impact area are realized.

6.4.1.5.4 Surface, ballistic, and other wind limits shall be established based on vehicle wind sensitivity.

6.4.1.5.5 Effective launch azimuth and elevation settings shall be established such that the planned impact shall occur within approved operating areas.

6.4.1.5.6 Launch limitations shall be published in the Flight Safety Plan.

6.4.1.6 Vehicles with Flight Termination Systems

6.4.1.6.1 Launch Limitations

6.4.1.6.1.1 Flight limits shall be established to implement flight safety criteria. Examples include: impact limits, vehicle attitude, heading, time of flight, and position. These limits may be implemented as launch criteria and/or flight requirements.

6.4.1.6.1.2 Surface, ballistic, and other wind limits shall be established based on vehicle wind sensitivity.

6.4.1.6.1.3 Effective launch azimuth and elevation settings shall be established such that the planned impact shall occur within approved operating areas.

6.4.1.6.1.4 Launch limitations shall be published in the Flight Safety Plan.

6.4.1.6.2 Flight Termination Criteria

6.4.1.6.2.1 Flight termination by the RSO is required when valid data shows the launch vehicle violating a flight termination boundary.

6.4.1.6.2.2 Flight termination is required when launch vehicle performance is unknown and the vehicle is capable of violating a flight termination boundary.

6.4.1.6.2.3 The vehicle Instantaneous Impact Point (IIP) shall not be permitted to overfly populated land areas unless the vehicle is flying within 5 sigma of nominal performance.

6.4.1.6.2.4 A flight may be terminated by the RSO as a result of gross trajectory deviation or obvious erratic flight. This action may be taken if, in the judgement of the RSO, further flight is likely to increase the hazard potential.

6.4.1.6.2.5 Other flight termination criteria may be enforced due to the uniqueness of a particular mission. These criteria shall be documented in the Flight Safety Plan.

6.4.1.6.3 Design Requirements

6.4.1.6.3.1 The Flight Termination System (FTS) for rockets, missiles, and drones shall meet all requirements specified in the Range Commanders Council (RCC) Document “Flight Termination Systems Commonalty Standard”, Standard 319-92 (Reference r).

6.4.1.6.3.2 The Flight Termination System for balloons shall meet the design requirements established by the National Scientific Balloon Facility (NSBF).

6.4.1.6.4 Prelaunch Checks

6.4.1.6.4.1 Flight Termination Systems for rockets, missiles, and drones shall be tested to certify the requirements specified in Reference r are implemented.

6.4.1.6.4.2 Flight Termination Systems for balloons shall be tested such that all requirements of the NSBF and the Federal Aviation Administration (FAA) are implemented.

6.4.1.6.4.2 Pre launch checks shall be performed to operationally certify the FTS system.

6.4.1.6.4.3 Ground support components of the flight termination command system shall be operationally certified.

6.4.1.6.4.4 Operational tests shall be performed to certify that the vehicle system operates within the RF limits specified by link analysis.

6.4.1.6.4.5 A functional test shall be performed during the countdown process to certify the flight termination system.

6.4.1.6.5 Data requirements

6.4.1.6.5.1 At least two independent data systems are required to provide real time positional/IIP data during launch. If one of the data systems is a skin tracking radar, a ceiling limitation shall be imposed to ensure visibility until the skin tracking radar has adequate time to provide quality data. The data systems shall be designed such that no single order vehicle failure mode or ground system failure mode could cause the loss of both data systems.

6.4.1.6.5.2 A loss of data, such that the Range Safety Officer (RSO) cannot certify vehicle performance within flight safety limits, shall result in a flight termination action.

6.4.1.6.5.3 All data systems, which provide information used to evaluate flight safety requirements, shall be certified prior to launch.

6.4.1.7 Weather Constraints for Expendable Launch Vehicle (ELV)

The weather constraints for ELV's is defined in Attachment 1.

6.4.2 Balloon Operations

6.4.2.1 All operations shall be conducted within flight limits which satisfy the risk criteria stated in 6.2.

6.4.2.2 A predicted trajectory shall be calculated based on the prelaunch wind profile. The predicted trajectory and its descent vector shall be updated based on the current wind profile.

6.4.2.3 A flight termination point and time shall be selected that satisfies the risk criteria. The time and location of the flight termination point shall be coordinated with, and clearance to terminate shall be obtained from the FAA or equivalent foreign agency.

6.4.2.4 A functional test of the flight termination system shall be performed prior to launch to certify the flight termination system.

6.4.3 Aircraft Operations

6.4.3.1 All aircraft operations managed by WFF or conducted on the GSFC/WFF test range shall be performed within the requirements established by an approved Operations and Safety Directives.

6.4.3.2 All operations shall be conducted such that the risk criteria stated in 6.2 are satisfied.

6.4.3.3 Aircraft shall be operated in accordance with the flight rules specified in the Aircraft Operations Manual for Wallops Flight Facility (Reference c), the National Airspace, Warning Area Airspace (VACAPES Operating Instruction 3120.1F, Reference t), or Oceanic Airspace, as applicable. Visual Meteorological Conditions (VMC) are required for all aircraft which are not Instrument Flight Rated (IFR).

6.4.3.4 For separation purposes, preassigned airspace and altitude boundaries shall be established prior to the mission for each participating aircraft. Minimum separation criteria is 1000 feet in altitude or 1 NM laterally unless formation flight is approved by the Aviation Safety Officer and a briefing with appropriate mission personnel is conducted prior to the start of the operation. Pilots shall retain the responsibility for aircraft separation; ground based coordinators shall only be used for position vectoring and advisories.

6.4.3.5 FACSFAC VACAPES shall be notified by aircraft prior to initial entry into the VACAPES area. If the aircraft is unable to notify FACSFAC, they should inform Wallops Range Control who shall notify FACSFAC.

7.0 RANGE USER AND TENANT RESPONSIBILITIES

7.1 Obtain approval prior to conducting any potentially hazardous operation.

7.2 Provide data to the GSFC/WFF for safety analysis. (See Section 8.0)

7.3 Identify the minimum safety requirements for test operations. If a range user or tenant determines that his safety requirements are more stringent than those imposed by the GSFC/WFF, he shall coordinate these requirements (through the Range Support Manager) with the GFSS.

7.4 Participate in discussions to familiarize GFSS personnel with all aspects of the mission.

7.5 Participate in real time data evaluation for mission control and/or flight termination, as required by the GFSS.

7.6 Notify the Range Support Manager of all meetings pertaining to the mission that involve safety related issues, i.e. Design Reviews, Operational Planning meetings.

7.7 Participate in failure/anomaly investigations and provide post flight data as required.

7.8 Provide a written waiver request, to the Range Support Manager, for any requirements specified in this document that cannot be satisfied.

8.0 GSFC/WFF SAFETY DATA REQUIREMENTS

8.1 Launch Vehicle and Payload Description Data

8.1.1 Hazardous Electrical Circuits - Range users shall provide the GSFC/WFF Range Support Manager with two readily distinguishable copies of schematic and wiring diagrams of all pyrotechnic and other circuits which initiate hazardous systems. The GFSS shall be promptly notified of any changes to hazardous electrical circuits.

8.1.2 Mechanical Systems - Range users shall provide a description, including technical details and precautions, for all hazardous mechanical systems. Scale drawings shall be supplied showing the location of these and all other hazardous systems (ordnance, pressure, etc.).

8.1.3 Ordnance Devices - For each EED, data sheets shall be provided listing the minimum all fire current, maximum no-fire current, recommended firing current, normal resistance, pin-to-case resistance, and, if available, the RF sensitivity characteristics. A technical description of all SAFE/ARM type devices (out-of-line S/A, S/A connectors, mechanical restraints, etc.) employed shall be provided. For ordnance devices such as: rocket motors, shape charges, detonating cord, etc. data sheets shall be provided which identify the DoD explosive classification, normal output characteristics, composition, or any other relevant information needed to perform safety analyses.

8.1.4 Chemicals - The range user shall provide a description and schematic diagram of the system. All hardware "plumbing", components (tanks, fittings, valves), and system safety features shall be defined. A Material Safety Data Sheet (MSDS) for each chemical used on the project shall also be provided.

8.1.5 Pressure Systems - The range user shall provide a description of all pressure systems used on the program. Technical characteristics, including design burst, proof, and MAWP pressures, internal volume, and materials of construction shall be provided.

8.1.6 Radiation Sources

8.1.6.1 Non-ionizing (RF) Sources - The range user shall provide data on all non-ionizing emitters including frequency, type of emission, type of radiating antenna, and radiated power (both peak and average).

8.1.6.2 Ionizing Sources - The range user shall provide data on all ionizing sources as required by Reference i: GHB 1860.1B, Radiation Protection -- Ionizing Radiation.

8.1.6.3 Optical Sources - The range user shall provide data on all hazardous optical emitter (e.g. lasers) including wavelength, pulse width, pulse repetition frequency, divergence angle, and power output.

8.1.7 Ground Support Equipment (GSE) - Range users shall provide schematics, drawings, operational description, technical details, and documentation of certification for all GSE used to support hazardous systems or operations. This includes but is not limited to pyrotechnic checkout meters, breakout boxes, calibration sources, pressure systems, chemical service modules, and lifting and handling devices. This requirement is in addition to the requirements of 5.3.5.

8.2 Operating Procedures

8.2.1 Hazardous Systems

Detailed procedures for handling, assembly, and checkout for all hazardous systems (ordnance, mechanical, pressure, chemical, etc.) shall be provided to GSFC/WFF prior to beginning operations.

8.2.2 Recovery

For recovery operations, procedures shall be provided which provide a description of the items to be recovered, reasons for recovery, hazards involved, and any recovery aids and their characteristics. These procedures shall describe the methods employed to verify that all hazardous systems are in a SAFE condition during recovery operations. A list of recovery aids such as chaff (frequency, quantity), locator beacons (frequency, power output, period of operation), dye marker (color persistence, time of deployment), flashing light (color, frequency, duration, candle power, directional characteristics), smoke (color, duration, time of deployment), radar reflective parachute (when deployed, size), or any other aids used should be included. Also, provide the desired period of recovery operations and the disposition of the recovered items.

8.2.3 Contingencies

Contingency procedures shall be provided prior to beginning operations. These contingency procedures include steps to be taken in the event of launch postponement, launch cancellation (including destaging), hold or abort, booster ignition failure, unintentional land impact, emergency response, chemical spill cleanup, or any other contingency which may endanger personnel or property.

8.2.4 Approval

All procedures for handling, assembly, and checkout of hazardous systems shall be approved by the Head, Ground and Flight Safety Section, Head, Launch Vehicles Branch, and the Reliability and Quality Assurance Officer prior to use at GSFC/WFF. Approvals shall be obtained prior to performing any potentially hazardous operation.

8.3 Performance and Flight Worthiness Data Requirements

8.3.1 The specifications defined in this section are intended as a synopsis for information required to perform a flight safety analysis. The actual requirements shall be mission specific. The range user is responsible for coordinating data requirements with the GFSS.

8.3.2 Rockets, Missiles, Drones and other similar vehicles

8.3.2.1 Provide a vehicle description including a scaled drawing and operating procedures.

8.3.2.2 Nominal Trajectory Inputs

8.3.2.2.1 For these operations, the minimum data requirements shall be sufficient to perform a five degree-of-freedom analysis.

8.3.2.2.2 Mass Properties - weights, inertias, and center of gravity.

8.3.2.2.3 Propulsion - thrust or chamber pressure.

8.3.2.2.4 Aerodynamics - drag, C_{Na}, C_{ma}, C_{mq}, C_{lp}, and C_{1d}.

8.3.2.2.5 Guidance and Control - guidance program, attitude gains, and attitude rate gains.

8.3.2.2.6 Launch Parameters - launcher settings, launch coordinates (WGS - 84 geodetic datum or other GFSS approved earth model), and a sequence of events (ignitions, burnouts, separations, etc.).

8.3.2.3 Trajectory Outputs

Output data may be required in printed, plotted, or computer medium format for each impacting or orbital body. The output should include:

8.3.2.3.1 Time, velocity, altitude, horizontal range, weight, thrust, drag, dynamic pressure, angle of attack, velocity vector elevation and azimuth angles, body elevation and azimuth angles, present position and instantaneous impact prediction latitude and longitude, "round earth" x, y, and z, slant range, azimuth, and elevation relative to the launcher, and control system forces, moments and deflections.

8.3.2.3.2 Maximum horizontal range, maximum velocity and turn rate analysis may be required.

8.3.2.4 Provide stability and dynamics analyses including flexible body, static margins, and a roll rate vs. pitching frequency.

8.3.2.5 Provide the results of an aeroelastic and structural analysis.

8.3.2.6 Provide the results of a thermal analysis.

8.3.2.7 Provide total dispersion data, either theoretical and/or empirical, in terms of one, two, and three sigma ellipses for all impacting bodies. The GFSS shall approve all techniques and values of error sources used in the dispersion analysis. A theoretical analysis shall include the following effects: thrust offset, thrust misalignment, aerodynamic errors, uncompensated wind, launcher misalignments, weight and impulse errors, guidance and control system errors, ignition delay, and any other errors unique to this vehicle. Provide flight history trajectory data on previous vehicle flights.

8.3.2.8 Provide a physical and mathematical description of all vehicle guidance and control systems.

8.3.2.9 Provide a debris analysis including technique and input parameters. The GFSS may elect to perform a debris analysis. Therefore, chamber pressure and the number and type of debris fragments caused by vehicle breakup shall be required. The data for each debris fragment shall include ballistic coefficient, weight, dimensions, drag coefficient, and the incremental velocity imparted by the vehicle breakup.

8.3.2.10 Provide a wind effect analysis and the method used for calculation. Provide data consistent with currently used GSFC/WFF wind compensation methods.

8.3.2.11 A Gross Hazard Analysis could be required on critical systems, depending on the project. Identification of each potential hazard, the preventive measures to reduce each potential hazard, and a risk assessment for those potential hazards which cannot be eliminated by preventive measures should be included in the Gross Hazards Analysis.

8.3.3 Balloons

8.3.3.1 Identify launch site and launch window.

8.3.3.2 Provide payload and balloon characteristics.

8.3.3.2.1 Payload dimensions and total suspended weight.

8.3.3.2.2 Balloon material, volume, and weight.

8.3.3.2.3 Gross inflation weight.

8.3.3.2.4 Theoretical stress index (if applicable).

8.3.3.3 Provide payload/parachute weight, drag coefficient, and reference area.

8.3.3.4 Provide the time of day (day or night) that each of the following mission phases will be performed: launch and ascent, float, descent and impact.

8.3.3.5 Provide anticipated float direction and duration of flight.

8.3.3.5.1 Float altitude.

8.3.3.5.2 Predicted float altitude variation during day/night cycle.

8.3.3.5.3 Float time or distance.

8.3.3.5.4 Float direction and estimated wind velocity at float altitude.

8.3.3.6 Provide description of any balloon control system (such as a valving system).

8.3.3.7 Provide balloon flight history data.

8.3.3.7.1 Balloon system reliability data including number of flights, number and types of failures, and where the failures occurred (ascent, float, or descent).

8.3.3.7.2 Actual and predicted payload/parachute descent vectors. Actual balloon descent vectors if available.

8.3.3.8 Provide balloon wind limitations.

8.3.4 Aircraft

8.3.4.1 The range user shall provide flight profiles including aircraft velocities, altitudes, and separations (for multiple aircraft).

8.3.4.2 Data on platform instrumentation shall be provided if it is of a hazardous nature (i.e. pressure systems, ordnance, gases, lasers, high-voltage, etc.).

8.4 Telemetry (TM) Data Requirements for Vehicles with Flight Termination

The specifications defined in this section are intended as a synopsis for pre-flight and real time data requirements. Actual requirements shall be mission specific and the range user is responsible for coordinating TM data requirements with the GFSS.

8.4.1 Command Receiver(s) signal strength (AGC) and check channel (command receiver channel 4).

8.4.2 Inertial Navigation System (INS) Parameters

8.4.2.1 Inertial position, velocity and acceleration. Inertial EFG coordinates are preferred. All reference systems shall be defined.

8.4.2.2 INS initialization parameters.

8.4.3 Guidance commands including nozzle deflections in the pitch and yaw axes.

8.4.4 Vehicle attitude data including pitch, yaw and roll angles and rates.

8.4.5 Motor Chamber pressures.

8.4.6 Flight Termination System (FTS).

8.4.6.1 Control circuit Status

8.4.6.2 External/internal battery voltage

8.4.6.3 Safe/Arm status

8.4.7 Global Positioning Satellite (GPS) positional and velocity data.

8.5 Schedule for Providing Required Data

8.5.1 NASA DoD and commercial ELV's shall meet the schedule defined in Attachment 2.

8.5.2 For sounding rocket vehicle or payload systems not previously launched from GSFC/WFF, all final data shall be supplied no later than T-90 days. Preliminary data for these systems shall be submitted no later than T-120 days.

8.5.3 For sounding rocket vehicle or payload systems previously launched from GSFC/WFF, final data shall be submitted no later than T-60 days. Preliminary data for these systems shall be submitted no later than T-120 days.

8.5.4 For balloon systems, all final data shall be supplied no later than T-30 days. If the payload contains hazardous systems, which are not covered by the general Balloon Ground Safety Plan or if the launch site/operations area is not contained in the Balloon Risk Model Population Data Base, the required data shall be submitted no later than T-90 days.

8.5.5 If deadlines are not met, GFSS may not be able to prepare all necessary safety plans in time to support a proposed flight. In every case, the mission shall not be conducted until adequate safety preparations are made.

8.6 Waivers

The range user shall provide a copy of any waiver for the launch vehicle or payload granted by another range.

8.7 Reviews

8.7.1 It is highly recommended GSFC/WFF Ground and Flight Safety personnel participate in Design and Mission Readiness Reviews for each mission. The Range User should notify Ground and Flight Safety personnel through the GSFC/WFF Range Support Manager at least ten days prior to conducting such reviews. Safety participation in such reviews may prevent costly engineering changes and scheduling delays.

8.7.2 Should GSFC/WFF not be represented at Design and Mission Readiness Reviews, a copy of the review material shall be submitted to GSFC/WFF as early as possible following the review.

ENCLOSURE A - Definitions

Active-Essential Personnel -- Those individuals whose activities contribute directly to the performance of a potentially hazardous operation which is actually under way, and whose presence is mandatory for completion of the operation.

Actual Burst Pressure -- The pressure at which pressure system components undergoing pressurize-to-burst testing rupture.

Burst Factor -- This quantity is equal to the MAWP divided by the design burst pressure.

Casualty Expectation -- The probabilistic number of casualties due to conduct of a mission.

Category "A" Systems -- Those systems which meet all the following; (1) initiation of the system could lead to a chain of events which result in injury or death to personnel or damage to property; (2) sufficient potential energy exists to initiate the device; and (3) the energy output of the system is not controlled by approved mechanical restraints or other safety devices.

Category “A/B” Systems -- Those systems which change from Category “B” to Category “A” during the various stages of processing. The change in hazard category is accomplished by utilizing approved out-of-line SAFE/ARM devices, mechanical restraining devices, employing the Man-Rated design requirements or by other approved means which reduce the effects of an inadvertent actuation to a nonhazardous condition or reduces the probability of occurrence to acceptable levels.

Category "B" Systems -- Those systems which (1) are highly improbable of being initiated, or (2) shall not cause injury to personnel or damage to property by either the expenditure of their own energy or the chain of events they initiate.

Caution Time -- That time period when any hazardous device or system is present in the hazard area and is in a safe inactive state. When a caution time exists, nonparticipating personnel are allowed to enter the launch area only when authorized by the Operations Safety Supervisor. Active-essential and standby-essential personnel continue working during a caution time.

Danger Area -- That area including impact areas, abort areas, storage areas, or Danger Areas resulting from a system malfunction in which the hazards from impacting objects, debris, or toxic materials exceed the established maximum acceptable risk level.

Danger Time -- That time period when any electrical operations, arming, explosive installation, launching, or other hazardous function is taking place.

Design Burst Pressure -- The pressure is a calculated test pressure that pressurized components shall withstand without rupture to demonstrate its design adequacy in a qualification test.

Electroexplosive Device (EED) -- An electric initiator or other component in which electrical energy is used to cause initiation of explosives contained therein.

Emergency System/Component -- An emergency system component is any system/component which prevents a hazardous event from occurring or escalating. These systems normally experience very few cycles, but their performance is extremely safety critical. Typical emergency components are relief valves and shut-off valves. Typical emergency systems are fire suppression systems and emergency purge/vent systems.

Flight Hardware -- includes all propellant tanks, pressure vessels, lines and components that constitute airborne equipment on a launch vehicle or payload.

Flight Hazard Area -- The operational area within which the risk due to impacting object(s) may exceed the established risk criteria.

Flight Safety -- A philosophy and methodology whereby rocket, balloon, drone, and aircraft flight operations can be performed in a reasonable and prudent manner without undue risk to people or property or embarrassment to NASA or the United States Government.

Ground Safety -- Those safety considerations, procedures, and resultant restrictions associated with hazardous systems during storage, handling, prelaunch, launch, and recovery/abort operations, where by operations can be performed in a reasonable and prudent manner without undue risk to people or property or the environment.

Hangfire -- A launch attempt where current to the vehicle initiator was delivered by the firing system and the vehicle failed to ignite as planned.

Impact Area -- The operational area within which one or more objects are predicted to impact in the vicinity of each other.

Inherently Safe -- The predicted trajectory of the vehicle is based solely on the launch and dispersion parameters and on known system errors.

Instantaneous Impact Point (IIP) -- The point at which an object would impact if thrusting were stopped at a given time.

Launch Abort -- Premature and abrupt termination of a launch attempt because of existing or imminent degradation of mission success probability or safety requirements.

Launch Area -- The area comprising rocket launching pads, a blockhouse, and auxiliary support facilities. For airborne launches, it is the defined operational hazard area which has been obtained from controlling authorities.

Launch Vehicle -- Any rocket, rocket system, or balloon that is used to launch a suborbital or orbital payload, probe, satellite, or other experiment.

Leak-Before-Burst (LBB) -- A fracture mechanics design concept in which it is shown that any initial flaw shall grow through the wall of the pressure vessel rather than bursting and causing catastrophic failure.

Maximum Allowable Working Pressure (MAWP) --The maximum operating pressure, to which operational personnel may be exposed, for a pressure system (vessel, tubing, piping, flex hose or component). This pressure is synonymous with Maximum Expected Operating Pressure (MEOP), as it is used and defined in MIL-STD-1522A.

Maximum Design Operating Pressure (MDOP) -- The system pressure rating based on structural and functional reliability. This is the pressure at which relief devices are set and is equal to 110% MOP.

Maximum Expected Operating Pressure (MEOP) -- This term, as defined in MIL-STD-1522A, is synonymous with MAWP. (See the definition for MAWP, as given above.)

Maximum Operating Pressure (MOP) -- The maximum pressure a system shall be subjected to during static and dynamic conditions. Usually this pressure is less than or equal to MAWP. This pressure may exceed MAWP as long as pressurization(s) are performed remotely. However, under no conditions shall MOP exceed proof pressure.

Megger Test -- A measurement performed on EED's using a megohmmeter to determine the pin-to-case insulation resistance. The test is performed at a known voltage (normally 500 volts) to verify that the insulation shall not break down and permit EED ignition in this mode.

Misfire -- A launch attempt in which current was not delivered to the vehicle initiator.

NOTAMS -- An advisory issued to airmen listing restricted or hazardous airspace during certain times.

NOTMARS -- An advisory issued to mariners listing restricted or hazardous areas during certain times.

Participating Personnel -- Those individuals who are participating in the operation.

Power Switching -- Power transfers where the net energy change exceeds 1.5 volts or 10 milliamperes.

Proof Pressure -- The test pressure applied to pressure systems or individual components without failure, leakage, or permanent deformation.

Public -- All people that are not participants in the operation.
Range Safety -- The ground and flight safety control associated with all phases of rocket, balloon, and aircraft operations.

System Initiator - Any device that initiates the action of a system. This includes but is not limited to electroexplosive devices, non-explosive initiators, and exploding bridgewire initiators.

TNT Equivalency -- The explosive energy per unit mass of the energetic material in question (propellants in our case) divided by the energy per unit mass of TNT; this number is usually expressed as a percentage.

ATTACHMENT 1

WEATHER CONSTRAINTS

FOR

EXPENDABLE LAUNCH VEHICLE (ELV)

The RSO must have clear and convincing evidence the following constraints are not violated.

1. Do not launch if any type of lightning is detected within 10 NM of the launch site or planned flight path within 30 minutes prior to launch, unless the meteorological condition that produced the lightning has moved more than 10 NM away from the launch site or planned flight path.

2. Do not launch if the planned flight path will carry the vehicle:

   a. Through cumulus clouds with tops higher than the +5°C level; or

   b Through or within 5 NM of cumulus clouds with tops higher than the -10°C level; or

   c Through or within 10 NM of cumulus clouds with tops higher than the -20°C level; or

   d Through or within 10 NM of the nearest edge of any cumulonimbus or thunderstorm cloud including its associated anvil.

3. Do not launch if at any time during the 15 minutes prior to launch time the one minute average of absolute electric field intensity at the ground exceeds 1 kilovolt per meter (1 kV/m) within 5 NM of the launch site unless:

   a There are no clouds within 10 NM of the launch site; and

   b Smoke or ground fog is clearly causing abnormal readings.

4. Do not launch if the planned flight path is through a vertically continuous layer of clouds with an overall depth of 4,500 feet or greater where any part of the clouds are located between the 0°C and the -20°C temperature levels.

5. Do not launch if the planned flight path is through any cloud types that extend to altitudes at or above the 0°C level and that are associated with <u>disturbed</u> weather within 5 NM of the flight path.

   DEFINITION: Disturbed weather is any meteorological phenomenon that is producing moderate or greater precipitation.

6. Do not launch through thunderstorm debris clouds, or within 5 NM of thunderstorm debris clouds not monitored by a field mill network or producing radar returns greater than or equal to 10DBz.

   DEFINITION: Debris Cloud is any cloud layer other than a thin fibrous layer, that has become detached from the parent cumulonimbus within 3 hours before launch.

<u>GOOD SENSE RULE:</u> Even when constraints are not violated, if any other hazardous weather conditions exist, the RSO may hold at any time based on the instability of the weather.

ATTACHMENT 2

DATA REQUIREMENTS

AND

REVIEW SCHEDULE

TIME			POC	INPUT	OUPUT
	START				
Issuance of MAD and AMIS	Project Initiation Conference (PIC)	Define Mission Objectives	-WFF RSM -Program MIM -P/L Mgr -L/V MIM	Description of Payload & Proposed Orbit Project team presentations	PIC minutes and action items
Prior to P/L PDR	Safety TIMs	Address Specific Safety Issues	WFF RSM P/L Mgr L/V MIM	Formal presentation of issues by project team & WFF Range Safety	TIM minutes Project status memo Action items Resolution
NLT L-18 months	P/L PDR	Define System Preliminary Hazard Analysis (PHA)		Project Team provides: Preliminary Safety Analysis Gross Hazard Analysis P/L Design Docs and Drawings Special Ops Preliminary trajectory	
PDR + 60 days	Preliminary Safety Data Package	User provides Preliminary Safety Document for Vehicle, P/L and Special Ops	WFF RSM P/L mgr L/V MIM	Project provides: Preliminary safety data for safety plan development	SDP for review

TIME			POC	INPUT	OUPUT
PDR + 60 days	Safety TIMs	Discuss SDP	WFF RSM P/L Mgr L/V MIM	Project Team presents: Traj Data Safety Analyses Facility mods Prelim Ops Plan	TIM Minutes Status Resolution Action Items
NLT L-12 months	P/L CDR	Finalize Design	WFF RSM P/L Mgr L/V MIM System Experts	Project Team presents: Final P/L design	Preliminary Safety Approval (subsystem) Final GHA
	Safety TIMs	Resolve Action Items and Safety Issues	WFF RSM P/L Mgr L/V MIM	Project team Identifies: Design changes Operational methods Testing	TIM Minutes documenting resolution of issues
CDR + 60 days	Operational Support System TIMs	Define Operational Support	WFF RSM P/L Mgr L/V MIM Mission Operations Mgr	Project Team presents: Mission Operation (data) requirements WFF Safety presents: Real Time Data requirements	RF Link Analysis Mission Support Allocation

TIME			POC	INPUT	OUPUT
L-75 days	Final SDP	User provides Final Safety document for Veh,P/L,&Ops	WFF RSM P/L Manager L/V MIM	Project provides Final Safety Data for safety plan develop	Approved SDP
L-75 days	Final Hazard Procedures Submittal	User submits to Range final procedures for all hazardous operations	WFF RSM P/L Manager L/V MIM	Project provides Procedures for hazardous operations	Proposed Hazardous Operations Procedures Document
L-75 days	System Safety A/I Resolution meeting	Attempt to close out safety action items	WFF RSM P/L Manager L/V MIM	Project team and WFF safety resolve all action items	Action Item close-out document
L-75 days	Environmental Test Results	Collect results for vehicle, P/L & A/C	WFF RSM P/L Manager L/V MIM	Project environmental team provides data	Test Result Reports
NLT L-60 days	Final Trajectory Tape to WFF	Project delivers final trajectory tape to WFF	WFF RSM P/L Manager L/V MIM	Project provides Trajectory data tape and inputs to WFF	Final Trajectory Tape (Required for Flight Plan Approval)
L-60 days	Final Flight Plan Submittal	Project delivers final Flight Plan for Aircraft Operations	WFF RSM P/L Manager	Project Provides Final A/C Ops Plan	Final Flight Plan
L-45 days	Operational Procedures Approval	Internal WFF approval of Operation Procedures	WFF RSM	WFF provides letter approving hazardous op procedures	Formal statement from WFF identifying approved procedures

TIME			POC	INPUT	OUPUT
L-30 days	Mission Safety Review	Closure of all Safety Action Items Definition of Safety Status	WFF RSM WFF Safety P/L Manager L/V MIM	Final Closure of Action Items by Project Team and WFF	Memo documenting Mission Safety Readiness
L-21 days	OSD	Define Operational Safety Plan Flight Safety Plan Ground Safety Plan Go/No-Go Items	WFF participating organizations	WFF provides: Flight Safety Plan Ground Safety Plan Go/No-Go Items OSD defines: Requirements Test directives Air ops plan	OSD
L-21 days	FTS Certification	Test Plan & documentation for FTS	WFF Safety L/V MIM	WFF defines FTS certification documents	FTS test plan and document
L-14 days	Mission Readiness Review	Determine readiness of range, P/L, vehicle and supporting sites	WFF RSM	Readiness Status	Readiness Status
L-5 days	Flight Readiness Review	Determine readiness of support A/C	WFF RSM	Readiness Status	Readiness Status
L-2 days	Launch Readiness Review	Review all prelaunch testing and certification	WFF RSM	Results of prelaunch testing and certification	Launch Readiness Certification
	LAUNCH				